ABSTRACT

Originally, the Iowa Department of Transportation (DOT) initiated this research project from an internal investigation relative to an increasing frequency of rough pavements developing early in the service life of grade and pave projects. Pavement roughness would typically be caused by differential settlement of the pavement supporting structure. This settlement could occur: (1) within the foundation soils supporting the embankment; (2) within the constructed embankment itself; (3) through softening of subgrade soils immediately under the pavement due to water infiltration; or (4) differential frost heave and shrink/swell. Although all of these are potential causes of differential settlement, this research focused on the one factor that we have the most control over which is the embankment itself. Phase I of the research program outlined problems associated with rough pavement as a result of poor embankment quality. Phase II research included the following: (1) develop and evaluate alternative soil design and embankment construction specifications based on soil type, moisture, density, stability, and compaction process; (2) assess various quality control and acceptance procedures with a variety of in-situ test methods including the Dual-Mass Dynamic Cone Penetrometer (DCP); and (3) develop and design rapid field soil identification methods. At the start of the research, soils were divided into cohesive and cohesionless soil types, with each category being addressed separately. Cohesionless soils were designated as having less than 36% fines content (material passing the No. 200 sieve) and cohesive soils as having greater than 36% fines content. Subsequently, soil categories were refined based not only on fines content but soil plasticity as well.

Research activities included observations of fill placement, in-place moisture and density testing, and dual-mass DCP index testing on several highway embankment projects throughout Iowa. Experiments involving rubber-tired and vibratory compaction, lift thickness changes, and disk aeration were carried out for the full range of Iowa soils. By testing for soil stability the DCP was found to be a valuable field tool for quality control whereby shortcomings from density testing (density gradients) were avoided. Furthermore, critical DCP index values were established based on soil type and compaction moisture content.

During fill placement, much of the fill material (cohesive and cohesionless) was typically very wet and compacted at high levels of saturation, which caused soil instability. It was observed that earthwork construction processes including lift thickness and roller passes were not consistent on several embankment projects. Compacted lift thickness was measured to vary from 7 to 22 inches and compaction effort averaged 4 to 5 roller passes. For cohesionless materials the research shows that sheepsfoot compaction is inadequate and that vibratory compaction increases uniformity and relative density. Also, it was observed that reduction of clod size for cohesive soils and aeration of wet soils by disking, which is currently a part of the Iowa DOT specifications, increases embankment quality but is rarely enforced in the field.

Subsurface explorations involving Cone Penetration Tests (CPT), Standard Penetration Tests (SPT), and Shelby tube sampling operations were performed at selected locations to